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PURPOSE AND MISSIONS

The Institute of Paper Science and Technology is a unique organization whose charitable, educational, and scientific purpose evolves from the singular relationship between the Institute and the pulp and paper industry which has existed since 1929. The purpose of the Institute is fulfilled through three missions, which are:

- to provide high quality students with a multidisciplinary graduate educational experience which is of the highest standard of excellence recognized by the national academic community and which enables them to perform to their maximum potential in a society with a technological base; and
- to sustain an international position of leadership in dynamic scientific research which is participated in by both students and faculty and which is focused on areas of significance to the pulp and paper industry; and
- to contribute to the economic and technical well-being of the nation through innovative educational, informational, and technical services.

ACCREDITATION

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RECYCLING RESEARCH AT IPST

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INTRODUCTION

The Institute of Paper Science and Technology (IPST) is very involved in research related to paper recycling. This research can be divided into three categories: (1) IPST Member-supported research, (2) student research, and (3) proprietary research. This article will briefly summarize the Member-supported and student research.

MEMBER-SUPPORTED RECYCLING RESEARCH

The Institute of Paper Science and Technology has 51 supporting members who assist in directing the Member-supported research. In the area of paper recycling, this research primarily addresses stickies control, flotation deinking fluid mechanics, and flotation deinking chemistry.

Stickies Control

Stickies are an unpredictable problem in recycling mills and are *the* major problem facing the recycling industry today. Some facilities live with stickies quite easily, some experience intermittent difficulties, and some mills are continuously plagued by them. The type of furnish accepted, the cleaning equipment used, and the chemicals applied, affect the frequency and severity of stickie outbreaks. Stickie problems are essentially an outcome of how stickies, fiber, and chemicals interact under the conditions prevalent in various stages of a recycle mill.

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Our approach to solving this problem is to attempt to understand how the various properties of these components affect agglomeration. In our initial work, we focused on the attachment of stickies to fiber. We found that high-kappa pulps were more prone to attract stickies, and that stickie agglomeration was interrupted by the presence of fiber; this meant that agglomeration was most likely to occur in the whitewater loop where the fiber level was the lowest. We are presently focusing on the properties of stickies alone, the interaction of stickies within mixtures, and their resistance to shear. For example, we find that turbulence can both induce and inhibit agglomeration. Stickies of low viscosity are disintegrated; in contrast, higher-viscosity stickies can be fused together in a turbulent medium. Figure 1 is a picture of our computer-controlled mixing tank where this research is conducted. Temperature, mixing rate, pH, air addition level, and chemical concentration can be controlled with this equipment. Finally, we are looking at how chemicals affect particle size and zeta potential, in an effort to match the correct type and amount of say, a dispersant, or a detackifier, to a given problem.

This research related to stickies control is being used at IPST to develop a usable stickie model based on laboratory-derived fundamentals and mill experiences that will provide stickie control solutions for a variety of problems.

Flotation Deinking Fluid Mechanics

Member-supported research at IPST related to flotation deinking fluid mechanics addresses bubble size control and bubble/particle interactions. These two areas are important for effective contaminant removal by flotation.

Before the bubble size can be controlled in a flotation cell, we must be able to measure the bubble size under conditions relevant to flotation deinking, including mixing intensity and consistency (~0.8-1.2%). At IPST, we have applied an x-ray technique, called flash x-ray radiography (FXR) to visualize air bubbles in pulp suspensions at consistencies as high as 1.5% (higher consistencies are possible, but have not yet been addressed). An example of bubbles rising in a pulp suspension at various ONP consistencies is shown in Fig. 2. FXR records the bubble size on film, and image analysis is then performed to record this parameter. Preliminary results have shown that bubble size increases with fiber consistency and bubble size is sensitive to the method of air injection. Experiments are now underway to investigate the effect system chemistry, fiber type, and fiber slurry velocity have on bubble size. The goal of this research is to develop methods to control bubble size that will provide conditions for optimal contaminant removal by flotation.

The interactions between air bubbles and contaminant particles are also being investigated to improve flotation cell performance. This research addresses the fundamentals of bubble/particle interactions with the goal of developing a flotation model that can be used in the mill to determine if a given process change will help or hinder deinking efficiency before an expensive trial is attempted. This model can also be used to optimize existing flotation equipment. An initial model has been developed, and we are now in the process of validating this model with bench-top flotation experiments.

Flotation Deinking Chemistry

In addition to the fluid mechanics of flotation, chemistry aspects of flotation are also being addressed at IPST. This area has a focus in surface chemistry interactions and chemistry affects on fiber loss and ink removal.

It is well-known that ink particle surface chemistry plays a significant roll in flotation deinking efficiency. The adsorption of deinking chemicals, particularly the surfactant, will modify ink surface properties. However, these effects are complicated and are not well understood. Part of our research is addressing the relationship between surfactant type and ink detachment from the fiber surface during repulping. It was determined that a nonionic surfactant, such as Triton X-100, can enhance ink detachment from the fiber surface during repulping, but a fatty acid will not significantly affect detachment.

Collectors are also important chemicals for effective flotation deinking. The function of different collectors, such as fatty acid/calcium complexes and cationic surfactants, and their roll in flotation deinking has been studied. Our experiments indicate that the toner retains its hydrophobicity after adsorbing fatty acid/calcium complexes. In contrast, toner hydrophobicity is reduced when kerosene, a common collector used in mineral flotation, is used.

Fiber loss during flotation deinking is another area under investigation from a chemistry point of view. Our research indicates that both fiber adhesion and physical entrainment contribute to fiber loss during flotation deinking, with fiber entrainment being the dominate factor. We have shown that froth stability and structure are two important factors affecting fiber entrainment and fiber loss. Therefore, to effectively reduce fiber loss during flotation deinking, the froth structure and stability must be well controlled.

Based on the above fundamental understanding of the flotation deinking process, an innovative approach using a simple surfactant delivery device to control several key process variables has been developed. Instead of adding surfactant into the pulp slurry directly before the flotation cell or in the repulper (as in a conventional process), a pressure atomizer is used to spray the surfactant solution from the top of the flotation column during flotation. Preliminary results (see Fig. 3) indicated that the surfactant spray approach can reduce fiber loss by 50%, water loss by 75%, and surfactant consumption by 95% without sacrificing deinking efficiency. This trend is observed even when the physicochemical properties of the pulp source vary.

For a period of time, it was not well understood what role old magazines (OMG) play in the improved brightness of recycled old newsprint (ONP) when it is deinked by flotation with a given percentage of OMG. Many people believed that the surface chemistry changes caused by the added OMG increased flotation efficiency, resulting in the increased brightness levels. A study carried out at IPST indicates that the addition of OMG into ONP deinking systems will not enhance the ink removal of ONP, and the brightness increase after flotation in the presence of OMG is solely caused by the introduction of filler and higher brightness fiber from the OMG.

STUDENT RECYCLING RESEARCH

In addition to Member-supported recycling research, we have a variety of student research projects that address paper recycling issues. Some of these projects are summarized below.

In the area of stickies control, we attempt to confirm our laboratory findings in the field, and we use students in these efforts, since it gets them inside a mill, and they are exposed to the dynamics and difficulties of a live operation. Students in this research typically take multiple samples from different streams in a recycle mill, and track the stickie distribution as the furnish moves through the process. We have an algorithm (available from us) that allows us to automatically identify individual stickies from an infra-red spectrum of the mixture. Using this, our students have identified the characteristics of stickies that survive screening and cleaning, and make it to the whitewater loop. Our goal is to reconcile our laboratory results with field experience so that workable solutions can emerge.

In the area of flotation deinking fluid mechanics, students are using FXR for fundamental studies. For example, we are currently identifying the effect fiber length has on bubble size at consistencies typical of flotation deinking. However, since most furnishes have a broad fiber length distribution, we are using Rayon fibers in this research. Preliminary results indicate that fiber length does influence bubble size.

In addition to FXR radiation techniques, students are also using gamma densitometry (gamma radiation) to measure how much air can be injected into a flowing pulp slurry. This parameter, called gas holdup or void fraction, is important for designing and operating flotation systems. Results with 0, 0.8, and 1.2% ONP slurries reveal that a maximum gas holdup is obtained at a consistency less than 1.2%, and this maximum is influenced by both the gas and liquid flow rate. Further studies in this area with bleached kraft fibers are being initiated.

Mixing also plays a key role in flotation deinking fluid mechanics, and student research is underway to investigate the influence fiber consistency has on the turbulence intensity and the size distribution of molten stickie (wax) particles. Preliminary results with synthetic fibers reveal a significant change in particle size distribution as consistency and mixing intensity increases. We are now initiating experiments with cellulose fibers to determine what effect fiber type and mixing rate have on particle size.

In the area of flotation deinking chemistry, student research is currently underway investigating the application of cationic surfactants as flotation collectors and frothers. These surfactants have been traditionally used as a collector for mineral flotation, but have not been used in flotation deinking. Our research addresses what effect cationic surfactants have on surface chemistry characteristics and deinking efficiency of ink particles.

Student research at IPST is also addressing the repulping process for toner-printed papers, with a particular focus on toner fracture as the paper swells. It has been shown that the ability to remove the toner is affected by the size and shape of toner particles that result from toner fracture during paper swelling. Ultimately, by understanding and controlling toner fracture, the resulting particle size may be more favorable to removal by flotation.

Finally, student research is being conducted at IPST addressing the wash deinking process and suspended solids particle removal. In this case, surface chemistry and fiber mat characteristics are the controlling parameters, whereas particle shape and density do not significantly influence suspended solids washing. By understanding the fundamentals of particle retention and removal in fiber mats, improved washing methods will be developed.

CONCLUSIONS

The research being conducted at IPST in the area of paper recycling primarily addresses stickies removal and control, flotation deinking fluid mechanics, flotation deinking chemistry, and particle size control and removal. These areas focus on improving existing recycling unit operations and devising new methods to enhance the recycling needs of the industry.

ACKNOWLEDGMENT

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Insert figure from slide showing mixing tank.

Figure 1: Computer-controlled mixing tank used at IPST for stickies research.

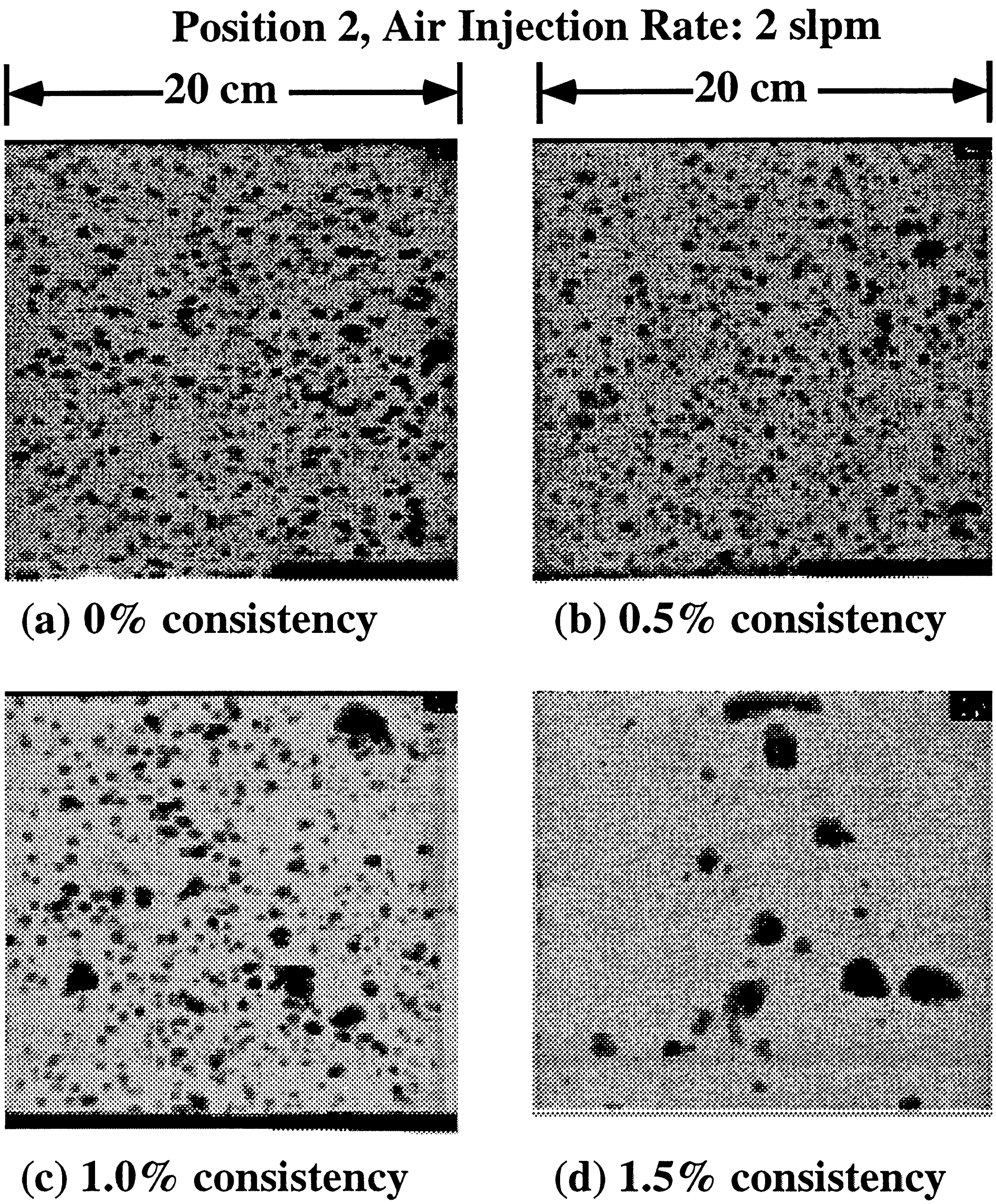

Figure 2: Flash x-ray radiographic images showing the effect ONP consistency has on bubble size. The dark regions are air bubble locations in this air/water/fiber system.

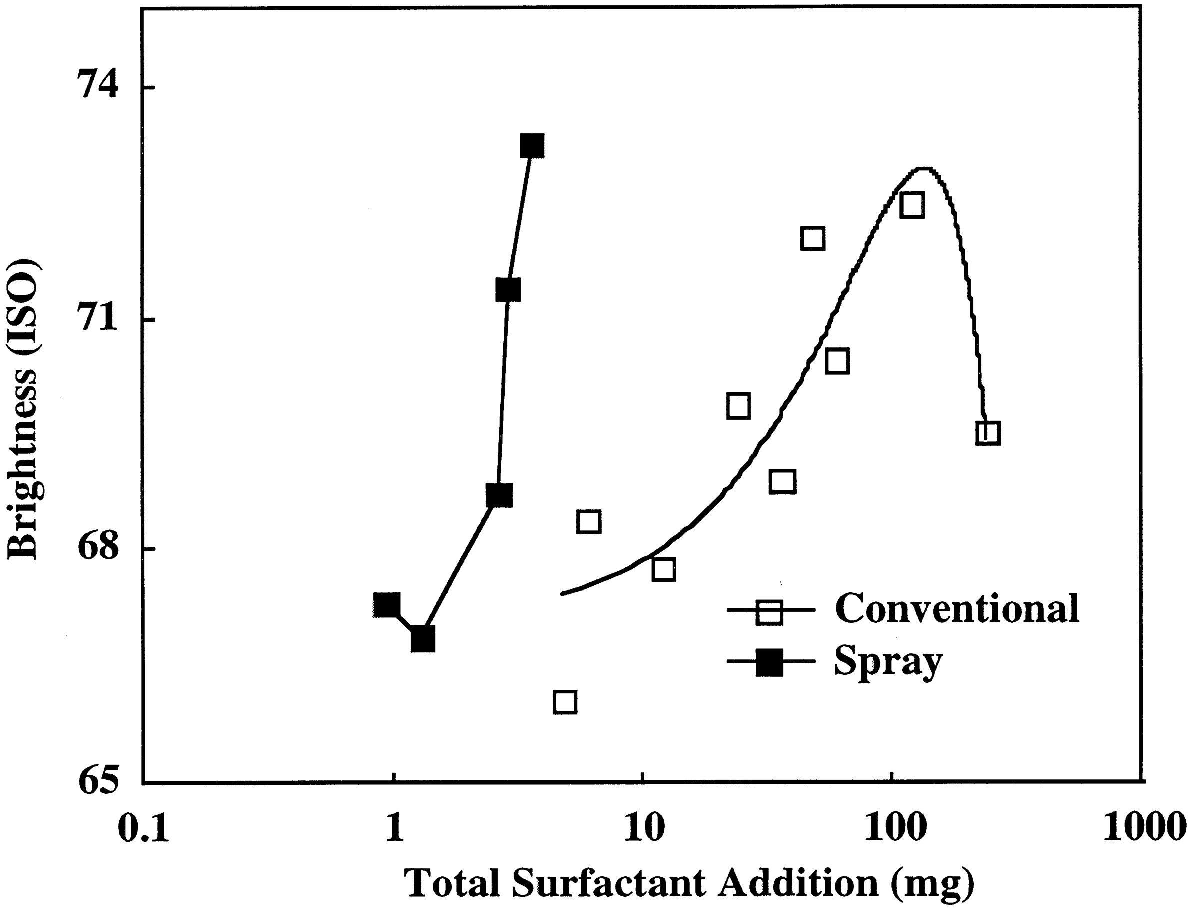

Figure 3: Brightness levels are maintained when the deinking surfactant is added with a spray, even though the surfactant usage has been reduced by 95% when compared to a conventional flotation process.